Regridding and Interpolation for Climate Data

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Summary

Climate models are increasingly using a variety of computational meshes on the sphere to address both numerical and physical needs. Displaced-pole, tripole, cubed-sphere and geodesic meshes are currently in use and next generation models are expected to use variable-resolution unstructured meshes. In order to facilitate intercomparisons of model results and to provide model output to decision-makers and other end users, we must be able to accurately interpolate model data from the computational meshes used for simulations to common latitude-longitude domains or observational data points. We are creating robust, general interpolation schemes for climate data and incorporating these schemes into common analysis frameworks.

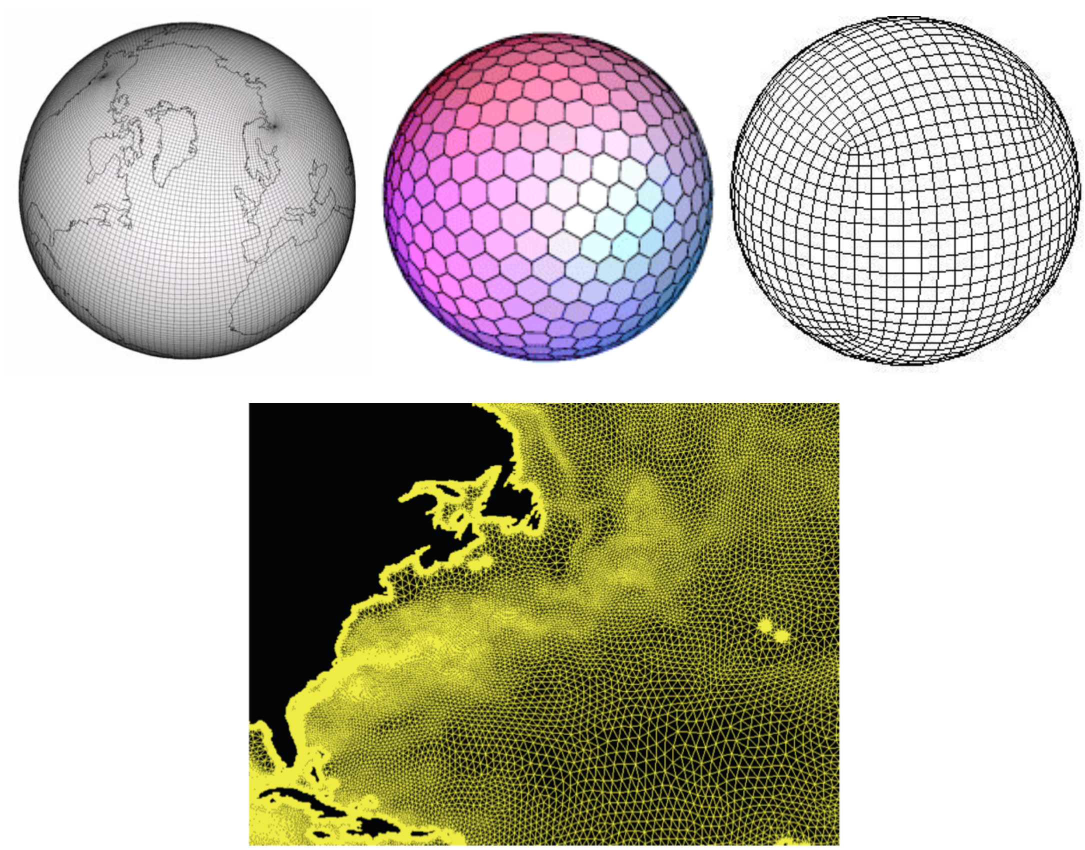

Figure 1. A sample of computational meshes used or considered for global climate simulation – tripole, geodesic, cubed-sphere, variable resolution Delaunay meshes.

To simulate the Earth's climate system, climate modelers must divide the Earth's surface into grid cells or meshes. In the past, these meshes have followed standard latitude-longitude coordinate systems for simplicity and ease of analysis. However, latitude-longitude meshes create numerical problems near the pole singularities. Numerical methods, like polar filtering, were designed to mitigate these mesh issues. Climate modelers then began to address the singularities directly by modifying the meshes themselves. For example, ocean modelers were able to design meshes in which the polar singularity is displaced into continental land masses and out of the computational domain (e.g. the tripole grid in Fig. 1). Other groups began to experiment with geodesic and cubed-sphere meshes (also shown in Fig. 1). For the next generation of models, climate scientists are exploring variable-resolution meshes or local refinement to both resolve important processes and provide regional detail to decision makers.

A move toward more flexible and general meshing schemes helps address issues in current global climate models, but it introduces new challenges for model analysis and coupling. Much of the analysis in climate science revolves around comparisons with observational data or with results from other models within a multi-model ensemble, an important driver for the Earth System Grid. Such comparisons are best performed on a common mesh and require fields to be interpolated or regridded to that mesh from the original computational mesh. In addition, many analyses require the interpolation to conserve properties of the field. This is also a requirement for passing fields between components of a coupled model system for the conservation of energy and water.

The Spherical Coordinate Remapping and Interpolation Package (SCRIP[2]) has been used in the climate community to create remapping and interpolation between any two grids on a sphere. This software has been included in a variety of model coupling and analysis frameworks, but has not been improved or updated since its release over 10 years ago. As a part of the Earth System Grid analysis capability, we must upgrade and improve SCRIP in a number of ways. First, while SCRIP has been used successfully for a variety of grids, there are many situations in which it is not as robust as it needs to be for an environment like ESG. We have developed new formulations that should greatly improve its robustness. Testing of these new formulations is currently under way. Second, a standard mesh specification has been developed and is gaining support within the climate science community. SCRIP is being updated to support these new mesh standards. Third, for high resolution simulations now being performed, SCRIP must be modified to support parallel computation of interpolation weights. As part of this effort, subroutine interfaces are being developed to enable analysis packages within ESG to call SCRIP in an on-line mode, rather than the current model of a standalone SCRIP computing interpolation information that is later re-used. These new interfaces will also enable externally-developed regridding methods to be more easily incorporated.

Future work will add new capabilities for new grids and new fields. Interpolation of vector fields (like winds and currents) are a particular challenge, especially when adding conservation constraints or maintaining divergence-free flow fields. The result will be a robust and flexible interpolation package for ESG-based analyses.

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[2]http://climate.lanl.gov/Software/SCRIP